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ABSTRACT. Familial factors related to lung function between six and 10 years of age have been studied among 1,160 children whose both parents were examined in 1975 in the French PAARC (Pollution Atmospherique et Affections Respiratoires Chroniques) Cooperative Study. The three indices FVC (forced vital capacity), FEV1 (forced expiratory volume in one second), and FEF25-75 (forced expiratory flow between 25 and 75 per cent of the vital capacity) were studied after adjustment for sex, town, age, and height (and weight for children's FVC and FEV1). Maternal (but not paternal) smoking was associated with a significant decrease in FEV1 and FEF25-75, but not in FVC. Familial resemblance was observed for all indices between children and parents and between siblings. None of the environmental factors considered (i.e.,parental smoking or education) or body habitus explained the familial resemblance observed. Conversely, after taking into account the aggregation between siblings, associations between children's lung function and parental characteristics (smoking, lung function) remained signficant. Parental-children correlations exhibited an increasing temporal trend with increasing age of the children. All but one correlation for FVC, FEV1, and FEF25-75 residuals of children with mothers' residuals were higher in the oldest age group compared with they youngest age group at the 0.10 level. Furthermore, correlations between siblings of opposite sex were significantly lower than correlations between siblings of like sex, especially for FEV1/FVC and FEF25-75/FVC. Results suggest that different growth patterns between boys and girls may be a critical factor in the study of lung function familial resemblance.

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FAMILIAL FACTORS RELATED TO LUNG FUNCTION IN CHILDREN AGED 6–10 YEARS

RESULTS FROM THE PAARC EPIDEMIOLOGIC STUDY

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Familial factors related to lung function between six and 10 years of age have been studied among 1,160 children whose both parents were examined in 1975 in the French PAARC (Pollution Atmosphérique et Affections Respiratoires Chroniques) Cooperative Study. The three indices FVC (forced vital capacity), FEV$_1$ (forced expiratory volume in one second), and FEF$_{25-75}$ (forced expiratory flow between 25 and 75 per cent of the vital capacity) were studied after adjustment for sex, town, age, and height (and weight for children's FVC and FEV$_1$). Maternal (but not paternal) smoking was associated with a significant decrease in FEV$_1$ and FEF$_{25-75}$, but not in FVC. Familial resemblance was observed for all indices between children and parents and between siblings. None of the environmental factors considered (i.e., parental smoking or education) or body habitus explained the familial resemblance observed. Conversely, after taking into account the aggregation between siblings, associations between children's lung function and parental characteristics (smoking, lung function) remained significant. Parental-children correlations exhibited an increasing temporal trend with increasing age of the children. All but one correlation for FVC, FEV$_1$, and FEF$_{25-75}$ residuals of children with mothers' residuals were higher in the oldest age group compared with the youngest age group at the 0.10 level. Furthermore, correlations between siblings of opposite sex were significantly lower than correlations between siblings of like sex, especially for FEV$_1$/FVC and FEF$_{25-75}$/FVC. Results suggest that different growth patterns between boys and girls may be a critical factor in the study of lung function familial resemblance.

child; education; growth; lung diseases, obstructive; tobacco smoke pollution

A number of epidemiologic studies have sought to investigate the influence of genetic and environmental factors on levels of lung function in children (1–6). All these

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Abbreviations: FEF$_{25-75}$, forced expiratory flow between 25 and 75 per cent of the vital capacity; FEV$_1$, forced expiratory volume in one second; FVC, forced vital capacity; PAARC, Pollution Atmosphérique et Affections Respiratoires Chroniques.

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studies have failed to adjust the statistical inferences for the nonindependence of the measurements of lung function that arises from the familial structure of the data (7). None of the studies have evaluated how different patterns of growth of lung function in children of both sexes (8) might influence the magnitude of the familial correlations observed.

In the current study, a subset of the PAARC (Pollution Atmosphérique et Affections Respiratoires Chroniques) survey (9) was used to investigate the influence of familial (genetic and environmental) factors on various measures of level of lung function (forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and forced expiratory flow between 25 and 75 per cent of the vital capacity (FEF_{25-75}) in children. The analysis uses a multivariate analytic technique (10) that permits both adjustments for the familial structure of the data and for covariates that might influence levels of function. Furthermore, a detailed analysis has been included that evaluates the effect of different patterns of lung growth in children on the observed familial correlations.

MATERIALS AND METHODS

The full data set of the French Cooperative Study PAARC includes 13,383 French households, each of which was headed by a nonmanual worker who resided for at least three years in one of 24 areas in seven French cities. The primary purpose of the larger study was to investigate the potential role of air pollution in the occurrence of respiratory symptoms and alterations in levels of pulmonary function in adults and children. The full protocol has been published elsewhere (9, 11).

Only adults aged 25–59 years (n = 20,246) and children aged 6–10 years (n = 2,979) were selected for the present study. From the full sample, a subset of 945 families, each of which included two parents and at least one child aged 6–10 years (n = 1,160: 557 girls and 603 boys), was selected for the present analysis on familial factors. The sample included 751 families with one child, 174 with two children, 19 with three children, and one with four children.

Subjects were interviewed at home by a questionnnaire derived from the British Medical Research Council/European Coal and Steel Community (BMRC/ECSC) (12) questionnaire. Parental smoking history was recorded through interviews with both parents. With respect to maternal educational level, families were classified into two groups—those who completed the primary level of schooling (low) and those who completed the secondary level or who obtained a university degree (high). Lung function was evaluated with a dry expirograph (Vitalograph, Buckingham, United Kingdom) performed on 95 per cent of the adults and 92 per cent of the children interviewed. At least three forced expirations were performed in accordance with ECSC recommendations (13). The FVC and forced FEV_1 expressed at ambient temperature, pressure, and water conditions were used for analysis. Measurements were made indoors with average temperatures ranging between 12 C and 30 C (with 98 per cent between 17 C and 25 C). In addition, the FEF_{25-75} of the time-volume curve was obtained from the curve with the largest FEV_1.

Seventy-eight per cent of the adults and 70 per cent of the children in the sample provided acceptable forced time-volume curves. Inadequate performance of the pul-

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monary function test was associated with lower levels of maternal education in both adults and children and with younger age among children. All subjects included in the present analysis provided acceptable forced time-volume tracings.

All measures of lung function were adjusted by means of regressions on age and height (14). They were calculated separately for adults and children by sex and by town, because there were discrepancies in the percentage of poor tracings and regression coefficients on age between towns. For children, weight was included in the regressions for FVC and FEV_1. After the adjustments, sex-specific normalized residuals were obtained for each measure of lung function according to the following:

Residual =

$$(\text{observed level} - (a_i\ \text{Age} + b_i\ \text{Height} + c_i))/\sqrt{s_i^2},$$

where i refers to ith town, a_i is the regression coefficient for age, b_i is the regression coefficient for height, c_i is the constant term (a coefficient for weight appears for children for FEV_1 and FVC), and s_i^2 is the residual variance. Linear regressions were used because it has been shown that over ages 6–10 years, the pulmonary function test is approximately linear with age (15), and little improvement of the multiple correlation coefficients (R^2) was obtained with more sophisticated models. Correlation coefficients for the regression of FVC (FEV_1) on age, height, and weight were 0.450 (0.401) for boys and 0.584 (0.493) for girls. Adding age^2 and height^2 terms only increased R^2 to 0.455 (0.404) and 0.588 (0.493), respectively. For FEF_{25-75}, correlation coefficients were much lower for boys ($R^2 = 0.14$) and for girls ($R^2 = 0.20$). These residuals are therefore adjusted for (weight) height, age, and town. For parents, height, age, town, and smoking residuals were computed by regression of the previous residuals on current cigarette tobacco use (g/day). These smoking-adjusted residuals also were normalized (mean ± standard deviation = 0 ± 1) to facilitate comparisons of associations with the different measures of lung function. The independence of the residuals used with age, height, weight, and, when appropriate, smoking was checked by careful examination of residuals plots. If a genetic factor exists, the correlations between children and the midparent (fictional subject to whom is attributed the mean value of both parents) should be the strongest. Residuals of midparents were computed as the mean of father and mother residuals. Air pollution varied according to the 24 areas and the seven cities (9). Since the primary purpose of the present analysis was to investigate the resemblance of town-adjusted lung function residuals of various household members exposed to the same pollution, air pollution will not be considered in the present report

Correlations of lung function between household members were evaluated by the adjusted pairwise correlated method of Rosner (16). This method permits the full use of all household members to compute the correlations between parents and children, while adjusting the test of significance for the intraclass correlations between siblings, i.e., for the nonindependence of the observations within a given household. A multivariate extension of this method (10) permitted adjustment of regression coefficients for the intraclass correlations among household members (especially siblings). Furthermore, it allows adjustment of intraclass correlations for various variables (such as environmental family characteristics).

Tests of statistical significance of familial correlations were one-sided, since the alternative hypothesis was that correlations between parents and children or between siblings were positive and not just different from zero (17). All other tests of significance were two-sided. In the multivariate analyses of correlations, differences in interclass correlations were evaluated by the introduction of the appropriate interaction terms in the models.

TABLE 1

Characteristics of sample of 945 households with two parents and one child, the French Cooperative Study PAARC

	Mothers (n = 945)	Fathers (n = 945)	Girls (n = 557)	Boys (n = 603)
Age	36.5 ± 5.9*	38.9 ± 6.4	8.8 ± 1.4	8.8 ± 1.4
Height (m)	1.62 ± 0.05	1.73 ± 0.06	1.29 ± 0.10	1.30 ± 0.09
Weight (kg)	56.2 ± 7.9	72.1 ± 9.5	27.3 ± 6.1	27.7 ± 5.4
Body mass index (weight (kg)/height (m)^2)	21.5 ± 2.8	24.1 ± 2.8	16.1 ± 2.1	16.2 ± 2.0
Ponderal index (height (m)/$^3\sqrt{\text{weight (kg)}}$)	42.3 ± 1.8	41.7 ± 1.7	43.3 ± 2.0	43.3 ± 1.9
FVC (liter)	3.29 ± 0.54	4.47 ± 0.75	1.73 ± 0.42	1.84 ± 0.43†
FEV_1 (liter)	2.68 ± 0.53	3.60 ± 0.71	1.50 ± 0.40	1.61 ± 0.40†
FEF_{25-75} (liter/sec)	2.97 ± 1.02	3.82 ± 1.34	1.92 ± 0.79	1.99 ± 0.75
FEV_1/FVC	0.814 ± 0.093	0.804 ± 0.084	0.867 ± 0.105	0.872 ± 0.089
FEF_{25-75}/FVC	0.906 ± 0.284	0.856 ± 0.275	1.12 ± 0.39	1.09 ± 0.37

* Mean ± standard deviation.

† Comparison between boys and girls (t test), $p < 0.001$.

RESULTS

The general characteristics of the study population are presented in table 1. Parents were relatively young, with a two-year difference between fathers and mothers. Girls had significantly lower values than boys for FEV_1 and FVC but not for FEF_{25-75} or for the ratios FEV_1/FVC and FEF_{25-75}/FVC.

The correlations for FVC, FEV_1, and FEF_{25-75} between children and parents and between spouses were significant (table 2). Correlations between children and mothers were higher than those between children and fathers, but statistical comparison was not possible because the data are not independent. Midparent-children correlations were similar to mother-children correlations. All intraclass correlations between siblings were significant.

Tobacco smoking by parents had the expected effect of decreasing their own measures of lung function (except FVC (table 3)). The strongest effects were observed for FEF_{25-75} in mothers and FEV_1 and FEF_{25-75} in fathers.

Significant effects of maternal smoking in all measures of lung function in children (except FVC) also were observed (table 3); the strongest effects were observed for FEF_{25-75}. Intraclass correlations were only slightly decreased after taking into account maternal smoking (table 3). Paternal smoking showed virtually no effect on level of function in children (table 3).

The above data suggest that maternal tobacco smoking might partially explain patterns of familial correlations observed in table 2, i.e., maternal-children correlations greater than paternal-children correlations for FVC, FEV_1, FEF_{25-75} and midparent correlations closer to maternal correlations for these same measures. Restriction of the analysis to those families in

TABLE 2

*Familial correlations of lung function residuals, French Cooperative Study PAARC; 945 families, 1,160 children**

	FVC	FEV_1	FEF_{25-75}
Between children and parents			
Mothers	0.26*	0.26	0.21
Midparents†	0.29	0.27	0.23
Fathers	0.19	0.15	0.16
Between spouses	0.18	0.20	0.23
Between siblings	0.30	0.34	0.27

* See Materials and Methods. All correlations between children and parents (adjusted pairwise test (16)), between spouses, and between siblings are significant at the 0.001 level (one-sided).

† Midparent residuals are the mean of father and mother residuals.

TABLE 3

Effect of parental smoking on lung function level and resemblance between siblings, French Cooperative Study PAARC†

	FVC	FEV_1	FEF_{25-75}
Maternal smoking‡			
Mothers' lung function§ (smoking (g¶/day))	−0.003	−0.013*	−0.024***
Children's lung function (smoking (g/day))	−0.002	−0.010*	−0.015**
Intraclass correlation (r)‖	0.30	0.33	0.26
Paternal smoking‡			
Fathers' lung function§ (smoking (g/day))	−0.015***	−0.019***	−0.018***
Children's lung function (smoking (g/day))	−0.001	−0.003	−0.004****
Intraclass correlation (r)‖	0.30	0.33	0.27

† The method used gives adjusted regression coefficients for the intraclass correlations and adjusted intraclass correlations for the variables included in the regression (10).

‡ Eleven per cent of the mothers were current smokers (11 ± 8 g/day); 58 per cent of the fathers were current smokers (17 ± 10 g/day).

§ Regression coefficients derived from regressions of parental smoking on height-, age-, town-, and (where appropriate) weight-adjusted residuals of lung function of parents and children.

‖ All intraclass correlations between siblings are significant at the 0.01 level.

¶ Grams of tobacco.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

**** $p < 0.10$.

which mothers never smoked (whether or not the father was a current smoker) had little effect on the pattern of parent-child correlations observed in table 2 (data not shown). Similar results were obtained when the height-, age-, and town-adjusted residuals of the parents' function also were adjusted for their current smoking by regression analysis and when these adjusted values were used to compute the parent-children correlations. Inclusion of the body build index of either the parents or children in the analysis did not alter the observed correlations between children's lung function residuals and parental lung function residuals. The familial resemblance was not abolished by looking within height/$\sqrt[3]{weight}$ (ponderal index) or weight/height^2 (body mass index) parental quintiles.

Maternal working status was investigated as an indirect measure of the mothers' contact time with their children. Among families with mothers who never smoked, 264 children had mothers who had never worked, 230 had mothers who had worked in the past, and 334 had mothers who were currently working. For FEF_{25-75}, a trend was observed in the magnitude of the maternal-children correlations: 0.29, 0.18, and 0.08 for mothers who had never worked, mothers who had worked in the past, and currently employed mothers, respectively. The difference in the correlations for mothers who had never worked and those currently working was significant ($p < 0.01$), based on the significance of the interaction term (current work • mother's FEF_{25-75} residual) in the regression of children's FEF_{25-75} residuals on the following variables: mother's FEF_{25-75} residual, current work (yes = 1, other = 0), past work (yes = 1, other = 0), current work • mother's residual, and past work • mother's residual. A nonsignificant trend was observed for FEV_1, and no trend was observed for FVC.

The influence of sociocultural factors on the correlations of lung function between parents and children was investigated through the evaluation of the effects of parental education on these correlations. In general, levels of lung function were lower for parents and children in households with the least educated mothers (table 4). Intraclass correlations between sib-

TABLE 4

Effect of educational level on lung function level and resemblance between siblings, 681 families with nonsmoking mothers, 828 children, French Cooperative Study PAARC†

Mean lung function residuals	FVC	FEV_1	FEF_{25-75}
Mothers' lung function			
Primary education vs. high‡	−0.15*	−0.14****	−0.14****
Fathers' lung function§			
Primary education vs. high‡	−0.25**	−0.27**	−0.16*
Children's lung function			
Mother's primary education vs. high‡	0.09	−0.01	−0.11
Intraclass correlation (r) between siblings	0.29	0.34	0.24

† The method used gives adjusted regression coefficients for the intraclass correlations and adjusted intraclass correlations for the variables included in the regression (10).

‡ Regression coefficients derived from regressions of education (high = 0, primary = 1) on residuals of lung function of parents and children (see Materials and Methods); 366 mothers and 323 fathers had a primary level of education.

§ All intraclass correlations are significant at the 0.001 level.

* $p < 0.05$.

** $p < 0.01$.

**** $p < 0.10$.

lings remained significant, after adjustment for maternal educational level. Within strata of maternal education, all correlations between mothers and children remained significant, and, with the exception of FEF_{25-75}, correlations between fathers and children were also significant.

Sex of the children did not have a consistent influence in parent-children correlations, although the correlations between girls and fathers were consistently higher than those between boys and fathers.

When the sibling correlations were computed taking into account the sex composition of the sibships, considerable variability was observed (table 5). Correlations between brothers were substantially higher than those between sisters for FEF_{25-75}. The correlation for FVC was significantly higher between sisters than between other siblings, and that for FEV_1 was comparable between brothers and sisters. In opposite-sex sibships, correlations were consistently lower than for like-sex sibships (except for FVC); differences were significant between the correlations for brothers and for opposite-sex siblings. These results suggest that sex-specific growth patterns were an important factor in the pattern observed for the correlations.

Figure 1 presents the relation between FVC, FEV_1, and FEF_{25-75} and age and height for girls. FEV_1 and FVC have a roughly linear relation with height. FEF_{25-75} appears to increase nonlinearly, with a spurt beginning at about eight years of age. For boys (figure 2), all measurements of function appear to grow in an approximately linear fashion until age 10, when there appears to be a further increase in FEF_{25-75} without an accompanying change in FEV_1 and FVC.

The ratios FEF_{25-75}/FVC and FEV_1/FVC, potential measures of "dysanapsis," that is, of the unequal growth of lung airways and parenchyma, were evaluated. Sibling correlations for the ratios (0.18 for FEV_1/FVC and 0.14 for FEF_{25-75}/FVC) were lower for these indices than were the correlations observed for FVC, FEV_1, or FEF_{25-75} (table 2). Similarly, for opposite-sex sibships, there was virtually no intraclass correlation for FEF_{25-75}/FVC. To further explore the relations noted in figures 1 and 2, regressions of FEV_1/FVC and FEF_{25-75}/FVC on height were carried out for seven different age-sex categories (figure 3). For males, the coefficients for height for FEF_{25-75}/FVC, and to a lesser extent for FEV_1/FVC, had significantly negative values up to the age range 87–96 months. Although only one of the regression coeffi-

TABLE 5

Intraclass correlations of lung function residuals, by sex of the siblings, French Cooperative Study PAARC

	FVC	FEV_1	FEF_{25-75}	FEV_1/FVC	FEF_{25-75}/FVC
Brothers (B) ($n = 50$)†	0.23‡	0.39	0.41	0.27	0.32
Sisters (S) ($n = 48$)	0.45	0.41	0.25	0.13	0.16
Opposite-sex sibs (BS) ($n = 112$)	0.21	0.25	0.20	0.11	0.01
Comparison§					
BS-B				*	**
BS-S	**				
B-S	****				

† Number of sibships.

‡ All correlations except sisters FEV_1/FVC ($p < 0.10$) and opposite sex FEF_{25-75}/FVC are significant at the 0.05 level.

§ Fisher's z test.

* $p < 0.05$.

** $p < 0.01$.

**** $p < 0.10$.

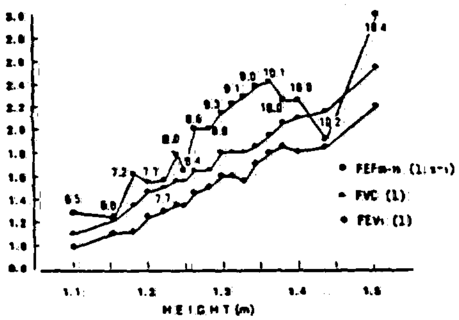

FIGURE 1. Lung function according to height and age for 557 girls, French Cooperative Study PAARC. Height was divided into 18 categories of approximately equal numbers of girls. Lung function values plotted are the median values of each height category, and median age values are figured on the graph. FVC and FEV_1 are expressed in liters, FEF_{25-75} in liters per second.

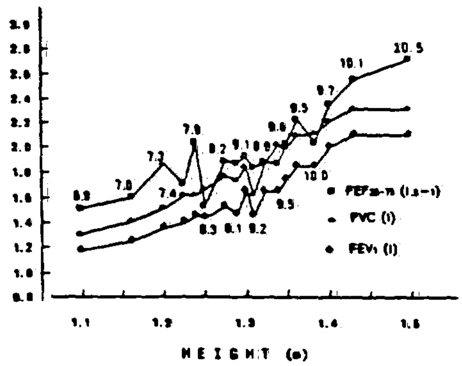

FIGURE 2. Lung function acccording to height and age for 603 boys, French Cooperative Study PAARC. Height was divided into 18 categories of approximately equal numbers of boys. Lung function values plotted are the median values of each height category, and median age values are figured on the graph. FVC and FEV_1 are expressed in liters, FEF_{25-75} in liters per second.

cients for height was significantly different from zero for girls (age range 96–105 months, $p = 0.07$), all were positive until ages 114–123 months. If height is taken as an index of growth, the negative coefficients for males indicate that over the entire age range studied, but especially up to the range of 96–105 months, FEF_{25-75} is growing at a slower rate than FVC.

The effect of the above differences in growth of lung function on the familial correlations is presented in table 6. Among girls, the correlations with maternal lung function increase in the age group 96–114 months for FVC and FEF_{25-75}. In the same age group, there is an increase in the correlations with fathers' FVC and FEV_1. Among boys, the increase in the correlation with mothers' lung function occurs in the oldest group (>114 months) for FVC; the increase in the correlation with maternal lung function occurs in the middle age group (96–114 months) for FEF_{25-75}.

DISCUSSION

The present investigation focuses on the factors that contribute to familial resemblance in lung function as observed in a

population-based cross-sectional study. As in previous investigations (1–3), familial resemblance has been observed, and the magnitude of the resemblance is similar to published results. In contrast to past investigations, the current work has made a detailed study of the extent to which a wide variety of intrinsic (e.g., age, sex, height, patterns of growth of lung function in children), environmental (e.g., parental smoking), and sociocultural (e.g., parental education) factors might be responsible for the familial resemblance observed. These factors have been taken into account in the analysis of the familial structure of the data.

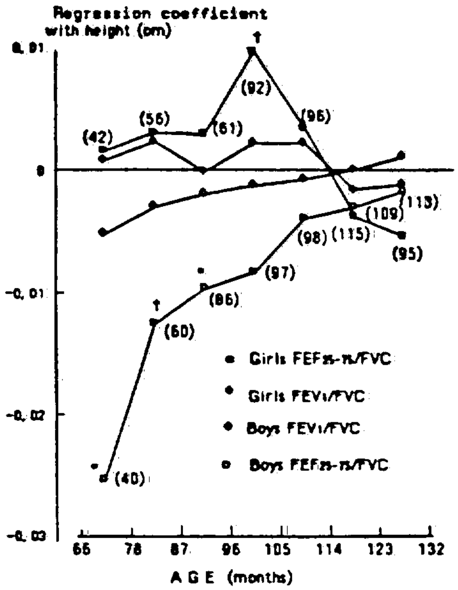

FIGURE 3. Sex-specific dysanaptic growth, French Cooperative Study PAARC. Dysanaptic growth refers to a disproportionate growth of airways and parenchyma. •, $p < 0.05$; †, $p < 0.10$.

The performance of an unacceptable tracing among children was associated with younger age, reported by others (18), and to a low maternal educational level. Familial resemblance in lung function was studied for age-adjusted indices and persisted after taking educational level into account. Therefore, exclusion of subjects with unacceptable tracings is unlikely to have seriously biased the estimation of the resemblance.

The extent to which familial resemblance in lung function is primarily a reflection of the tendency for family members to have a similar body habitus has been a source of controversy (2). Lebowitz et al. (6) did not observe aggregation of pulmonary function after adjustment for ponderal index (height/$^3\sqrt{\text{weight}}$). Body habitus (ponderal index or body mass index) did not affect the magnitude of the parental-children correlations for FVC, FEV_1, or FEF_{25-75} in the present work.

A factor that might account for some of

TABLE 6

*Correlations of adjusted lung function residuals between parents and children, by sex and age of the children, French Cooperative Study PAARC**

Sex and age (months)	FVC		FEV_1		FEF_{25-75}	
	Mothers	Fathers	Mothers	Fathers	Mothers	Fathers
Girls						
66–95 (n = 159)	0.14	0.10†	0.26	0.04†	0.13	0.15
96–114 (n = 188)	0.30	0.22	0.30	0.21	0.28	0.13
115–132 (n = 210)	0.28	0.22	0.21	0.22	0.30	0.23
Boys						
66–95 (n = 186)	0.18	0.14	0.17	0.17	0.07†	0.13
96–114 (n = 195)	0.13	0.20	0.25	0.10†	0.20	0.15
115–132 (n = 222)	0.41	0.18	0.33	0.11†	0.23	0.12

* All correlations of children with mothers' residuals in the oldest age group were higher, at least at the 0.10 level, than correlations in the youngest age group, except for FEV_1 among girls, for whom the increase in correlation coefficients was significant with fathers' values (Fisher's z test).

† Not significant at the 0.05 level (one-sided test).

the divergence in the results related to body size is the different pattern of growth in lung function observed between boys and girls. Different patterns of airway-parenchymal-somatic growth relations in the two sexes have already been described by Pagtakhan et al. (19). They reported that among girls a rapid growth of smaller airways which outgrows lung development during somatic growth seems to occur before puberty. In the present study, as indicated in figures 1–3, girls aged 6–10 years showed a pattern of increase in lung function measurements characterized by a more rapid growth rate in flows (FEF$_{25-75}$) relative to volumes (FEV$_1$, FVC) up through ages 8.75 years, with a "spurt" in flow growth at about age eight years. Such mid-growth spurt has already been noticed for various indices such as height (20) or chest circumference (21). In contrast, boys showed growth of FEF$_{25-75}$ that was relatively slower than that observed for volumes, but which progressively increased over the age range 6–10 years (figure 3). When parent-child correlations were calculated for the different growth stages of the children, increases were observed in the correlations, particularly for maternal-child correlations. Such temporal variation in familial resemblance is well known during the pubertal spurt for factors markedly genetically determined, such as height (22). Failure to take into account the heterogeneity in the parent-children correlations according to growth patterns, especially in small samples, could account for some of the previous divergence in the published results.

For all measures of lung function evaluated, correlations in like-sex sibships were always higher than those observed for opposite-sex sibships, which further supports the influence of the growth phenomena on the pattern of observed correlations. The observation that there was a distinct trend toward a decrease in the magnitude of the correlations for FEF$_{25-75}$ and FEF$_{25-75}$/FVC from male-sex sibships to opposite-sex sibships would be expected on the basis of the growth data in figures 1–3. This explanation cannot easily be invoked to account for the pattern of correlations for FVC. However, in the case of FEV$_1$, the near identity between same-sex sibships would be expected, as would a decrease in magnitude for opposite-sex sibships. The results may also explain, in part, the small correlations in opposite-sex sibships observed by Higgins and Keller (1) and Devor and Crawford (23), although in the former study subjects were generally older than in the present work (age data are not given in the study by Devor and Crawford). The pattern of correlations between 5.5 and 40 years of age according to the data of the PAARC and Tecumseh studies suggests that maternal factors, prenatal or postnatal, have a substantial effect on the phenotypic expression of lung function for girls and boys through the mid-teenage years. During the teens, the sex-specific environment of children, partly derived from their parents, exerts increasing effects. By adulthood, children do not generally share a common environment with their parents, in which case, the influence of their personal environment increases the variability of lung function and thus reduces the apparent magnitude of the familial effect (1).

Investigation of parental smoking habits revealed that age-, height-, town-, and, where appropriate, weight-adjusted levels of lung function in children were significantly lower in children with mothers who smoked (table 3). No effect was seen for paternal smoking. These results are consistent with other reported data (18, 24–27). Furthermore, since French mothers who smoke generally belong to a higher educational group and French fathers who smoke to a lower educational group (11), the effect of maternal smoking as well as the lack of association with paternal smoking are unlikely due to social class confounders. Recently, a significant effect of paternal smoking on children's lung function values was reported, but these children were older (8–16 years) and lived in crowded homes (28).

As expected, mothers who smoked had a lower body mass index. Therefore, adjustment for maternal ponderal index may lead to an underestimate of the effect of maternal smoking. Furthermore, if a low body mass index relates to a susceptibility among smokers (possibly genetically controlled) to lower lung function (29, 30), adjustment for maternal body mass index may lead to an underestimate of resemblance (in terms of lung function) between mothers and children. In the present study, associations between children's lung function and maternal smoking persisted after taking into account the nonindependence of siblings, which confirmed and extended the results of Burchfiel et al. in Tecumseh (31).

A greater time spent by the mother with the young child is a possible explanation of the effect observed with maternal smoking (26, 27). Supporting this hypothesis is the stronger influence of mother's smoking than of father's smoking on children's salivary cotinine (32). Maternal smoking during pregnancy also may have some effect on lung development that carries over into early childhood. This would be consistent with the growth-retarding effect on fetus rats in relation to maternal smoking (33) and to the effect of maternal smoking on height (34). No direct estimate of maternal smoking during pregnancy was available in this study, nor were enough mothers ex-smokers to evaluate this point indirectly.

For most of the children, the mother was present when the spirometric exam was performed, but this does not explain the higher correlations observed with the mothers because the same pattern was observed when the father was present (4). The proximity of the mother, indirectly assessed by her working status (never, past, current) suggests that, independent of smoking, correlations for FEF_{25-75} between children and mothers are markedly influenced by proximity and, therefore, by postnatal factors. An alternative explanation of this finding might be the existence of important factors modifying maternal FEF_{25-75} among working mothers, but no significant association has been observed in the PAARC population between occupational exposures and FEF_{25-75} among women (35).

In conclusion, the results suggest that growth patterns and their particular characteristics for each sex appear to be critical factors in the study of familial resemblance of lung function.

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